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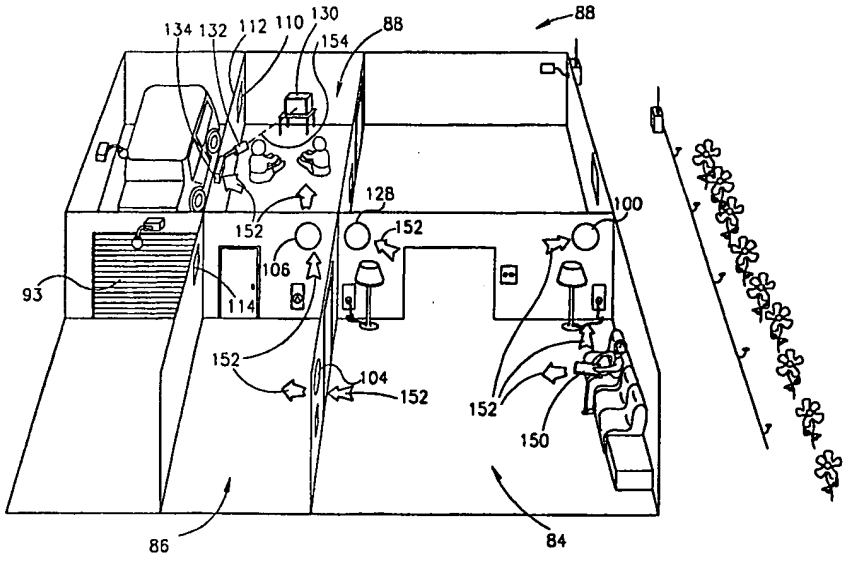

(57) Abstract

A remote-control system is provided for controlling a plurality of devices located in different rooms of a structure and areas in the vicinity of the structure comprising: at least one user operated controller for generating wireless command signals encoding data; a control unit for each of the plurality of devices that receives wireless command signals generated by the at least one controller and controls a device responsive to data in a wireless command signal that it receives; a wireless communications network comprising at least one transceiver that transmits wireless command signals from one side to the other of a wall of the structure; wherein the at least one controller transmits command signals that are routed to a control unit of a device of the plurality of devices through the at least one transceiver.

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REMOTE-CONTROL SYSTEM FOR APPLIANCES

FIELD OF THE INVENTION

The present invention relates to remote control of appliances, equipment and power outlets located in rooms of a building and in grounds and areas in the vicinity of a building.

BACKGROUND OF THE INVENTION

As more and more appliances and pieces of equipment crowd our homes and places of work it becomes ever more convenient and in some cases necessary to control and program appliances and equipment remotely.

Remote-control systems for operating appliances, equipment and different types of devices and apparatus, hereinafter referred to collectively as "appliances", in rooms of a building and grounds surrounding a building are known. Many of these systems are limited in the number of appliances that they can control or are limited to controlling appliances in a single room or localized area of a building. Remote-control systems that are designed to control a large number of appliances in a relatively extended area of a building are often complicated and costly to install.

US Patent 5,109,222 to J. Welty, which is incorporated herein by reference, describes a remote-control system that comprises a computer for controlling appliances located in a plurality of rooms in a building. The computer is located in one of the rooms in the building and is wired to sensors in rooms of the building in which appliances controlled by the system are located. The computer generates control signals that control appliances in the building in response to signals, hereinafter referred to as "command signals" received by the sensors. Command signals are generated by a user of the remote-control system and input to the computer when the user operates a controller while pointing the controller at the sensor. Each command signal identifies an appliance that the user wishes to control and an action the user wants the appliance to perform. A control signal generated by the computer in response to the command signal is generally transmitted by wire to an appropriate terminal in a room in which the identified appliance is located. From the terminal the control signal is transmitted to the appliance over a wire or by a wireless transmission such as by IR, RF or UHF. Appliances controlled through the system transmit signals back to the controller that comprise information about states of the appliances. The controller is described as preferably having a visual display for displaying information received from the appliances.

Since installing the system in a building requires hardwiring the computer to sensors and terminals in rooms in the building, installing the system generally requires "burying" wires

in walls and/or ceilings of the building. Installing and burying wire is a relatively expensive, labor intensive task that is time consuming and bothersome.

US patent 3,590,271 to Peters, which is incorporated herein by reference, describes controlling power to a power-outlet mounted in a recess in a wall of a room using a controller that generates ultrasound signals. The controller is a battery operated controller that can be mounted to a wall in the room with glue. A receiving unit, which is mounted in the recess in which the power-outlet is installed, receives ultrasound signals generated by the controller. The receiving unit operates a switch to control power to the outlet responsive to the ultrasound signals

US patent 5,099,193 to Moseley et al, which is incorporated herein by reference, describes controlling power to a power-outlet in a room using wireless signals transmitted from a hand held or wall mounted controller. Signals generated by the controller may be IR, RF or ultrasound signals.

US patent 5,382,193 to Thaler, which is incorporated herein by reference, describes a remote-control system for controlling a plurality of appliances in a room. Each appliance is connected to a control unit identified by an address. The control unit controls the appliance responsive to command signals generated by an IR controller operated by a user in the room. A command signal is encoded with an address of a control unit and an action to be executed by an appliance connected to the control unit. In a preferred embodiment, the remote-control system comprises a transceiver in the room that receives signals from the controller and amplifies and retransmits them to the appliances. The control units and transceiver are programmable so that different combinations of settings or states of the appliances can be stored and called up with a single command signal generated by the controller.

US Patent 5,554,979, to H. Kohar, which is incorporated herein by reference, describes a "point and operate" system for controlling appliances in a localized space or a room of a building. Each appliance controlled by the system is connected to its own control unit that has a receiver for receiving signals from a hand held controller. The hand held controller comprises a directional transmitter, such as a narrow beam IR transmitter. A user of the system controls an appliance by pointing the controller at the receiver of the control unit connected to the appliance and pressing appropriate buttons on the hand held controller. At any one time only appliances, generally located in a single room, that are connected to a receiver lying along a line of sight to the user are controllable by the user.

It is desirable to have a remote-control system that is easy to install and that enables a user to control appliances located in a plurality of rooms of a building from any one of the plurality of the rooms. It is desirable that the remote-control system is easily reconfigured to increase or decrease the number of appliances operated through the system and the number of rooms or areas in which appliances controlled by the system are located.

SUMMARY OF THE INVENTION

Aspects of some preferred embodiments of the present invention relate to providing a remote-control system that is easily installed and one that enables a user to control any one of a plurality of appliances located in different rooms of a building from any one of the rooms. The system is easily reconfigured to change the number of appliances operated through the system and the number of rooms or areas in which appliances controlled by the system are located.

An aspect of some preferred embodiments of the present invention relates to providing a remote-control system for controlling a plurality of appliances that comprises a wireless communication network. The communications network "covers" a plurality of rooms in a building and/or areas in grounds near to the building. Command signals from a user of the system are transmitted by the communications network to appliances that the user controls. The appliances may be located in any of the rooms and areas covered by the communications system and the user can control each of the appliances from any of the rooms or areas covered by the communications system.

In a preferred embodiment of the present invention, the user operates a controller to generate non-directional command signals that are used to control appliances in the system. A controller may be a portable hand held unit or a stationary unit installed in a fixed location in a room or area covered by the remote-control system.

Each appliance in the system is coupled to a unit, hereinafter referred to as an "activation module", that is identified by an address. The activation module has a sensor for receiving command signals and preferably a signal processor for processing command signals. A command signal encodes an address of the activation module of an appliance that the user wants to operate and data defining an activity that the user wants the appliance to execute. When the sensor of an activation module receives a command signal, the processor processes the command signal to determine if the address encoded in the command signal is the same as the activation module identifying address. If it is, the activation module generates a control signal that controls the appliance to which it is coupled to execute the activity encoded in the command signal.

Command signals generated by a user operating a controller are transmitted by the communications network between rooms and areas of the building to reach the appliances for which they are intended. The communications network comprises at least one transceiver through which command signals are routed from the controller to appliances. Preferably, the command signals are relatively short-range non-focused ultrasound, IR, RF or UHF signals. Command signals generated by a controller or transceiver are preferably substantially confined to the room or area in which they are generated. The only way in which a command signal generated in one room or area covered by the system reaches another room or area covered by the system is by being received and retransmitted by at least one transceiver. The communications network may therefore be considered to be a cellular communications network in which the cells of the network are the individual rooms or areas in and around the building covered by the network.

Preferably, each transceiver of the at least one transceiver selectively transmits command signals that it receives. A transceiver transmits only those command signals that it receives that have to be transmitted in order for the command signals to reach the appliances for which they are intended. Transceivers preferably comprise programmable processors for processing command signals and determining which command signals received by a transceiver are to be retransmitted by the transceiver.

According to an aspect of some preferred embodiments of the present invention, an activation module senses information relevant to the functioning of an appliance that it controls. Preferably, the activation module controls the appliance responsive to both command signals that it receives and the information that it senses.

Some activation modules, in accordance with a preferred embodiment of the present invention, generate signals that encode information that they sense relevant to the functioning of an appliance they control. The signals, hereinafter referred to as a "data signals", are received by a controller operated by a user. A data signal may reach a controller directly from the activation module if the controller is in the same room as the activation module. Otherwise, the data signal is routed through the communication network to reach the controller.

According to an aspect of some preferred embodiments of the present invention an activation unit controls an appliance to which it is connected responsive to data signals that it receives from other activation units. For example, a first light in a room might be turned on if its activation module receives a data signal from an activation module of a second light in the room indicating that a light bulb in the second light has burnt out.

An aspect of some preferred embodiments of the present invention relates to providing an activation module that controls supply of electrical power from an electrical junction box to at least one power-outlet that draws power from the junction box. The activation module controls power to the at least one outlet by controlling at least one switch that connects or disconnects a wire from the junction box to the at least one power-outlet from a power line in the junction box. Preferably, when power is disconnected from the power-outlet the wire to the power-outlet is grounded. In some preferred embodiments of the present invention, the activation module also senses current supplied to the at least one outlet and opens the switch if the current exceeds a safe maximum current.

An advantage of locating the activation module in the junction box is that when the at least one power-outlet is not in use, wires from the junction box to the power-outlet have substantially no voltage on them. This provides an added safety feature for power systems in a building, in accordance with a preferred embodiment of the present invention. At any one time the length of wire in or on the walls of the building that are "live" is reduced. This reduces the probability of the occurrence of accidents resulting from damaged or aged live power lines in and on the walls of the building.

In some preferred embodiments of the present invention, an activation module controls power to a plurality of power outlets from a junction box that provides multiphase-phase electrical power. Electrical power in each phase is supplied on a different power line in the junction box. Preferably, the activation module senses the amount of power provided by each of the power lines to power outlets connected to the power line. Preferably, the activation module connects the power outlets to the power lines responsive to the sensed amount of power provided by each power line so that at any one time all power lines in the junction box provide substantially the same amount of power.

According to an aspect of some preferred embodiments of the present invention, command signals and data signals are ultrasound signals. Address data and data defining an activity that an appliance is to execute or a state of an appliance are preferably encoded in the ultrasound command signals by frequency coding. Preferably, an ultrasound signal comprises a train of ultrasound pulses and each ultrasound pulse is frequency coded.

Transceivers, activation modules and controllers (stationary controllers as well as portable ones) of a remote-control system in accordance with a preferred embodiment of the present invention do not have to be connected by wires. (However, in some preferred embodiments of the present invention some of these components may be connected by wires.)

Furthermore, the system is "decentralized" and does not require a central computer. Components of the system that are required to process data are provided with their own data processor. In addition, since command signals and control signals are substantially non-directional signals, transceivers, activation modules and controllers do not have to be aimed at each other in order to communicate signals to each other.

A remote-control system in accordance with a preferred embodiment of the present invention is therefore a modularized system comprising components that are very easy to install and operate. As a result, a remote-control system in accordance with a preferred embodiment of the present invention is easily expanded to increase the number of rooms covered by the system and the number of appliances operated through the system.

There is therefore provided in accordance with a preferred embodiment of the present invention, a remote-control system for controlling a plurality of devices located in different rooms of a structure and areas in the vicinity of the structure comprising: at least one user operated controller for generating wireless command signals encoding data; a control unit for each of the plurality of devices that receives wireless command signals generated by the at least one controller and controls a device responsive to data in a wireless command signal that it receives; a wireless communications network comprising at least one transceiver that transmits wireless command signals from one side to the other of a wall of the structure; wherein the at least one controller transmits command signals that are routed to a control unit of a device of the plurality of devices through the at least one transceiver.

Preferably, each control unit is identified by an address. Preferably, at least one controller encodes data that identifies an address of a control unit of a device and an action for the device to execute in a wireless command signal that the at least one controller transmits and when the control unit identified by the address receives the wireless command signal the control unit controls the device to execute the action.

The at least one transceiver, preferably, selectively transmits a wireless signal that it receives from one side of the wall to the other side of the wall responsive to the address encoded in the wireless signal and from which side of the wall the command signal is received.

Preferably, the at least one transceiver comprises a memory stored with an address of at least one of the control units. Preferably, the at least one transceiver transmits a wireless command signal from one to the other side of the wall responsive to the address stored in the memory. Alternatively or additionally, addresses in the memory are preferably changeable.

In some remote-control systems in accordance with preferred embodiments of the present invention, a control unit of at least one of the plurality of devices comprises a transceiver. Preferably, when the transceiver receives a wireless command signal generated by the at least one controller having an address that is the same as the address of the control unit, the control unit controls the at least one of the plurality of devices to execute an action defined by data encoded in the wireless command signal.

In some preferred embodiments of the present invention, at least one control unit connects or disconnects power from a junction box to at least one power outlet by controlling at least one switch that connects or disconnects a wire from the at least one power outlet to or from a power line in the junction box. Preferably, the at least one controller and switch are located in the junction box.

In some preferred embodiments of the present invention, at least one control unit senses information relevant to the functioning of a device of the plurality of devices that the control unit controls. Preferably, the at least one control unit controls the device responsive to the information. Alternatively or additionally, the at least one control unit preferably generates wireless data signals encoding the information.

Preferably, at least one control unit generates wireless data signals responsive to wireless command signals that the at lest one control unit receives from a controller of the at least one controller. Additionally or alternatively, at least one controller preferably comprises a receiver for the wireless data signals. Preferably, the at least one controller comprises a display which displays information encoded in wireless data signals that it receives. Alternatively or additionally, the at least one controller preferably generates wireless command signals to control a device responsive to wireless data signals that it receives.

Additionally or alternatively, at least one control unit preferably comprises a receiver for the wireless data signals and controls a device of the plurality of devices responsive to wireless data signals that it receives.

Additionally or alternatively, at least one control unit preferably generates wireless data signals that are transmitted to their intended receivers via the communication network.

In some preferred embodiments of the present invention at least one controller is a hand held controller. In some preferred embodiments of the present invention at least one controller is a controller mounted in a fixed position.

In some preferred embodiments of the present invention the wireless signals are ultrasound signals. Preferably, each of the ultrasound signals comprises a pulse train of

ultrasound pulses. Preferably, sound waves in each ultrasound pulse are restricted to a narrow band of frequencies centered about a central frequency. Preferably, the central frequency for each ultrasound pulse is a frequency of a plurality of frequencies in a band of frequencies having a minimum frequency and a maximum frequency. Preferably, the minimum frequency is greater than or equal to 35 kHz. Additionally or alternatively, the maximum frequency is less than or equal to 48 kHz. Additionally or alternatively, the ultrasound pulses in the pulse train have a same duration. Preferably, the pulse rate for the pulse train is constant.

In some preferred embodiments of the present invention at least one controller is programmable to generate wireless command signals responsive to a program. Preferably, at least one controller comprises a clock that provides timing signals and the at least one controller is programmable to generate wireless command signals responsive to the timing signals.

In some preferred embodiments of the present invention at least one controller is operable to transmit command signals responsive to signals transmitted through a telephone.

In some preferred embodiments of the present invention at least one controller generates a wireless electromagnetic signal in addition to an ultrasound command signal when the at least one controller generates an ultrasound command signal.

Preferably, at least one control unit comprises a receiver that receives electromagnetic signals and when the at least one control unit receives an electromagnetic signal and an ultrasound command signal, the at least one control unit activates a device responsive to a time difference between the arrival of the electromagnetic signal and the ultrasound signal. Alternatively or additionally, the electromagnetic signal is preferably an RF signal. Alternatively or additionally, if the electromagnetic signal is not an RF signal, preferably the electromagnetic signal is an IR signal.

There is further provided, in accordance with a preferred embodiment of the present invention, a control unit for controlling power to at least one power outlet from a junction box to which power is provided on at least one power line comprising: at least one switch mounted in the junction box that selectively connects a power line in the junction box to a wire from each of the at least one power outlet that brings power from the junction box to the power outlet; a receiver that receives wireless command signals from a controller of the at least one controller that encode data; and circuitry that controls the at least one switch to selectively connect the wire to a power line in the junction box responsive to the data in a wireless command signal that it receives.

Preferably, the control unit senses information relevant to power supplied from the junction box to the at least one power outlet and controls the at least one switch responsive to the information that it senses. Preferably, the control unit comprises circuitry that generates data signals that encode information that the control unit senses. Alternatively or additionally, the control unit preferably senses if a load is connected to the at least one power outlet and if a load is not connected to the power outlet, disconnects the wire that supplies power to the at least one power outlet from the power line. Additionally or alternatively, the control unit senses power supplied to each of the power outlets and disconnects power to an outlet in case of overload of the outlet.

In some preferred embodiments of the present invention, the at least one power outlet comprises a plurality of power outlets. Preferably, the at least one power line comprises a plurality of power lines. The control unit preferably senses the amount of power supplied to the plurality of power outlets on each of the plurality of power lines and connects wires that provide power to the power outlets from the junction box to the power lines so that each of the power lines provides substantially the same amount of power to the power outlets.

In some preferred embodiments of the present invention, each power line that provides power to the junction box provides power from a different phase of a multiphase power source.

In some preferred embodiments of the present invention, the wireless command signal is an ultrasound signal. Alternatively or additionally, the data signal is preferably a wireless data signal. Additionally or alternatively, the data signal is an ultrasound signal.

BRIEF DESCRIPTION OF FIGURES

The invention will be more clearly understood by reference to the following description of preferred embodiments thereof read in conjunction with the figures attached hereto. In the figures, identical structures, elements or parts which appear in more than one figure are labeled with the same numeral in all the figures in which they appear. The figures are:

Figs. 1A - 1D show schematically components of a remote-control system for controlling appliances using ultrasound command signals, in accordance with a preferred embodiment of the present invention; and

Figs. 2A - 2D show schematically a cut-away perspective view of a ground floor of a house in which a remote-control system is installed to control appliances in the house, in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 1A shows schematically a hand held controller 20 for generating frequency coded ultrasound command signals used in controlling appliances in a remote-control system, in accordance with a preferred embodiment of the present invention. A user of the remote-control system operates controller 20 to generate substantially non-directional ultrasound command signals that encode an address of an appliance that the user wants to control and an action that the user wants the appliance to execute. The user operates controller 20 by one of or a combination of methods known in the art for operating electronic devices, such as by positioning a slide control, pressing a touch pad or depressing control buttons. Controller 20 is shown having control buttons 22.

In accordance with a preferred embodiment of the present invention, command signals generated by controller 20 encode address data and "action data" in a pulse train of "n" ultrasound pulses. Each ultrasound pulse has a frequency chosen from a set of "m" frequencies located in a band of frequencies defined by a minimum frequency and a maximum frequency. Preferably, the minimum and maximum frequencies are 35 kHz and 48 kHz respectively. The total number of different command signals that can be generated by controller 20 is therefore n^m.

In Fig. 1A controller 20 is shown generating a command signal 24 comprising a pulse train 26 of six ultrasound pulses 28. Except for the first and last ultrasound pulses 28, each ultrasound pulse is shown, by way of example, having a different frequency. The number of ultrasound pulses in command signal 24 and the particular choice of frequencies shown is arbitrary and have been chosen for convenience of presentation.

Whereas pulse train 26 is schematically shown as being radiated in single direction, pulse train 26 is preferably substantially non-directional and is radiated into a solid angle of over 2π steradians. Pulse train 26 is shown unidirectional for convenience of presentation.

Preferably, each ultrasound pulse 28 in pulse train 26 has a same duration. Each ultrasound pulse 28 is preferably generated following a same delay time after a preceding ultrasound pulse 28 in pulse train 26 is radiated. The delay time is schematically shown as a space 30 between any two consecutive pulses 28 in pulse train 26.

Delay time 30 is useful in reducing interference between a pulse 28 and reflections of a previous pulse 28 in command signal 24 that are simultaneously received by a unit receiving command signal 24. For example, if controller 20 radiates ultrasound command signal 24 in a room, reflected pulses from ultrasound pulses 28 will "rattle around" the room, repeatedly

being reflected off various surfaces in the room. As an ultrasound pulse is repeatedly reflected it loses energy. Therefore if delay time 30 is large enough, at the time at which one ultrasound pulse 28 is radiated, most of the energy in the room from previous ultrasound pulses 28 is dissipated. As a result, at any one time, a receiver, for example of an activation module or a transceiver in the room, picks up energy from substantially only one ultrasound pulse 28 at a time. Time delay 30 effectively "insulates" one ultrasound pulse 28 in command signal 24 from the other ultrasound pulses 28 in the command signal.

In addition to hand held controllers of the type shown in Fig. 1A, command signals can be generated, in accordance with a preferred embodiment of the present invention, by stationary controllers that do not require wiring to a power source. In some stationary controllers, a battery or photocell installed in the stationary controller powers the controllers. Preferably, a stationary controller comprises both a chargeable battery and a photocell that generates power from ambient light to charge the battery. A stationary controller may therefore be easily mounted, for example with glue, double-sided tape or screws, to any convenient surface region, such as a surface region of a wall of a building in which a remote-control system, in accordance with a preferred embodiment of the present invention is installed.

Some controllers, in accordance with preferred embodiments of the present invention, are appliance specific controllers that control a single appliance such as a light, a ceiling fan or an air conditioning unit. Command signals generated by these controllers, generally stationary controllers, always encode a same single address, *i.e.* that of the activation unit of the appliance that they control. Other controllers control a relatively small number of appliances. Still others control a substantially unlimited number of appliances.

In accordance with a preferred embodiment of the present invention some activation modules identify a command signal from a controller not by an address encoded in the command signal but by a position of the controller sending the command signal. These activation modules comprise a receiver for ultrasound command signals and an additional receiver for electromagnetic signals, for example RF or IR signals. A controller that controls an activation module of this type sends out two signals in order to control the activation module, an electromagnetic signal and an ultrasound signal. The activation module receives both signals and processes the signals to determine a time difference between their arrival at the activation module. From the time difference, the activation module determines a location for the controller sending the command signal. If the controller location is recognized by the activation module the activation module, executes an instruction in the ultrasound signal. In some

preferred embodiments of the present invention a command signal is the electromagnetic signal and the ultrasound signal is used primarily to determine the location of the controller.

In accordance with preferred embodiments of the present invention, some controllers are not only able to generate ultrasound signals but are also capable of receiving ultrasound data signals generated by activation modules. Controllers of this type are equipped with a means, such as a flat screen or indicating lights, for presenting information coded in data signals to a user of the controller.

Fig. 1B shows a block diagram of a transceiver 40 for relaying command signals in a communication network in a remote-control system, in accordance with a preferred embodiment of the present invention. Transceiver 40 comprises two preferably identical ultrasound transducers 42 and 43 for sensing and generating ultrasound command signals. Ultrasound transducers 42 and 43 may be formed, for example, from piezoelectric vibrators. Transceiver 40 preferably selectively retransmits on one of ultrasound transducers 42 and 43 command signals received on the other of ultrasound transducers 42 and 43.

Ultrasound transducers 42 and 43 are preferably coupled to a signal preprocessing circuit 44 and a signal-generating circuit 46. Preferably, transceiver 40 comprises a processor 48, which is connected to signal preprocessing circuit 44 and signal-generating circuit 46.

When an ultrasound command signal is sensed by an ultrasound transducer 42 or 43 the ultrasound transducer 42 or 43 generates an electronic output signal. The output signal is homologous to the ultrasound command signal and preserves information encoded in the ultrasound command signal. The output signal is preferably amplified, filtered and thresholded by preprocessing circuit 44 to provide a preprocessed signal that is input to processor 48.

Processor 48 processes the preprocessed signal to determine if the ultrasound command signal should be retransmitted. Processor 48 preferably determines whether to retransmit the command signal depending upon the address encoded in the command signal and which ultrasound transducer receives the command signal. Determining which of ultrasound transducers 42 or 43 receives a command signal incident on transducer 40 is preferably done by determining which of the ultrasound transducers registers a more intense stimulus in response to the command signal. This is readily accomplished using thresholding techniques to filter signals received from transducers 42 and 43.

Preferably, transceiver 40 has a memory in which addresses of appliances operated through the system are stored. Each stored address is associated with one of ultrasonic transducers 42 and 43. When a signal is received by processor 48 from preprocessor 44,

processor 48 checks the memory to see if the address encoded in the signal is one that is associated with the ultrasonic transducer 42 or 43 which received the command signal. If it is, processor 48 generates control signals that are input to signal-generating circuit 46. In response to the control signals, signal-generating circuit 46 generates signals that control the other one of ultrasound transducers 42 or 43 to transmit the received ultrasound command signal.

For example, assume that ultrasound transducer 42 receives a command signal encoding an address "A1". If A1 is associated with ultrasound transducer 42, then transceiver 40 retransmits the command signal from ultrasound transducer 43. If A1 is not associated with ultrasound transducer 42, transceiver 40 does not retransmit the command signal. The same command signal received on ultrasound transducer 43 will preferably not be retransmitted by ultrasound transducer 42. Transceiver 40 is therefore, preferably, a "one way transceiver" for command signals that it receives. Signals encoding a particular address are transmitted through transceiver 40 in one direction only. As a result, transceiver 40 does not retransmit a command signal that it receives back to the source from which it received the command signal. Furthermore, transceiver 40 can be programmed to transmit only command signals that have to be transmitted in order for the command signals to reach appliances for which they are intended.

Fig. 1C schematically shows transceiver 40 mounted in a wall 50 separating two rooms (not shown) of a building. A command signal 52 received from controller 20 on one side of wall 50, i.e. in one of the rooms, is retransmitted to the other side of wall 50 by transceiver 40, i.e. to the other one of the rooms.

Fig. 1D shows schematically an activation module 60 for receiving ultrasound command signals and converting them to signals for controlling a switch 62. Switch 62 may be for example, a switch that connects a power line in an electrical junction box to a wire that supplies power from the junction box to a power outlet.

Switch 62 can be closed and opened responsive to a command signal received by activation module 60 to turn on and turn off power to the outlet and thereby to turn on or off an appliance plugged in to the outlet. Power to the power-outlet can be turned off for safety reasons by opening switch 62 when nothing is connected to the outlet. Mounting activation module 60 in a junction box provides an added safety feature for the power outlet. When power to the outlet is off, the wire that carries power from the junction box to the outlet does not have any voltage. This reduces the probability of accidents resulting from the wire being damaged by age or accident while there is voltage on the line.

Activation module 60 comprises an ultrasound transducer 64 for receiving ultrasound command signals connected to a signal processing circuit 66. Circuit 66 preferably comprises a a memory (not shown). Circuit 66 is connected to a transducer 70 that generates control signals to control switch 62 responsive to signals from circuit 66. An address is stored in the memory that identifies activation module 60. Circuit 66 processes output signals generated by ultrasound transducer 64 in response to command signals and determines if a command signal received by ultrasound transducer 64 encodes an address that matches the address stored in the memory. If the address encoded in the command signal is the same as the address stored in memory, circuit 66 transmits signals to transducer 70. In response to the transmitted signals, transducer 70 generates control signals that control switch 62 to open or close in accordance with data comprised in the command signal.

Preferably, circuit 66 is connected to a sensor 72 that senses whether or not a load is connected to the power-outlet and/or the amount of current flowing through switch 62 and transmits output signals responsive thereto to circuit 66. Preferably, circuit 66 controls switch 62 responsive to output signals received from sensor 72. For example, if sensor 72 determines that all appliances connected to the power-outlet are turned off, circuit 66 controls transducer 70 to open switch 62. When an appliance that is connected to the power-outlet is turned on, sensor 72 senses a load connected to the power outlet and circuit 66 controls transducer 70 to close switch 62. If sensor 72 senses that current through switch 62 exceeds a maximum safe current, circuit 66 controls transducer 70 to open switch 62. In some activation modules similar to activation module 60, in accordance with a preferred embodiment of the present invention, circuit 66 controls ultrasound transducer 64 to generate data signals encoded with data responsive to the status of switch 62 and/or current sensed by sensor 72. An activation module of this type can alert a user to a situation that requires the user's intervention. For example, if switch 62 is opened because of an overload in a circuit. a data signal indicating the overload may be sent to a controller in use by the user. In response to the data signal the controller may display a message to alert the user to the situation on a visual display or flash a warning light. The data signal may be sent to a control module that controls an alarm. In response to the data signal, the control module controls the alarm to generate an alarm signal that alerts the user that user intervention is required.

Neither the user nor the alarm of course has to be in the same room in which switch 62 is installed. The data signal reaches the user or the alarm, in accordance with a preferred

embodiment of the present invention, via the communication network of the remote-control system.

Whereas activation module 60 is shown controlling a switch, activation modules similar to activation module 60 can be used to control and report the status (by generating data signals) of other devices such as a light, an air conditioner or an IR or RF signal generator that in turn generates signals to control an appliance. Activation modules, in accordance with a preferred embodiment of the present invention, can also be used to control and report on the status of systems, such as for example a heating system.

Activation modules, in accordance with a preferred embodiment of the present invention that generate data signals to indicate the state of devices or systems that they control may generate data signals in situations other than those that demand user intervention. For example, some activation modules, in accordance with preferred embodiments of the present invention, are programmable to periodically generate data signals. In accordance with preferred embodiments of the present invention, some activation modules are programmable to generate data signals responsive to particular states of the appliances that they control, or to changes in these states. Some activation modules are controllable, in accordance with a preferred embodiment of the present invention, to generate data signals "upon request", responsive to command signals they receive from a user. For example, an activation module that controls a thermostat of a heating system used to control temperature in a room might generate a data signal encoding the room temperature upon request by the user.

In many cases it is advantageous to have a unit, in accordance with a preferred embodiment of the present invention, that functions as both an activation module and a transceiver. Such a unit, hereinafter referred to as a "combination unit", is identified by an address in the same way that an activation module is identified by an address. When a combination unit receives a command signal comprising an address that is the same as its own identifying address, the combination unit does not retransmit the command signal. Instead, it controls the appliance to which it is connected to execute an action responsive to data comprised in the command signal.

In particular, it is convenient to have a combination unit for use in controlling power to wall mounted power outlets in a building. Generally, a building is provided with many wall mounted power outlets and these receive power from power lines located in electrical junction boxes installed in recesses in the walls. Generally, each room of a building has many junction boxes and the junction box recesses are, or can be made, relatively spacious. As a result,

substantially all transceivers required to install a remote-control system in a building, in accordance with a preferred embodiment of the present invention, can conveniently be installed in recesses provided for junction boxes. Installing the transceivers in junction box recesses already provided in a building simplifies installation of the remote-control system and reduces installation costs. Furthermore, if a transceiver installed in a junction box recess is part of a combination unit, the combination unit can be used to control power to a power-outlet connected to power lines in the junction box. Appliances plugged into the power-outlet can be turned on or off by command signals transmitted to the combination unit.

Figs. 2A – 2D show schematically, a remote-control system in accordance with a preferred embodiment of the present invention, installed in a ground floor 80 of a house and illustrate how the remote-control system functions. Sizes of components of the remote-control system and other features of Figs. 2A - 2D are not shown to scale but have been chosen for clarity of presentation.

In Figs. 2A – 2D ground floor 80 is shown schematically in a cut-away perspective view. Ground floor 80 comprises a kitchen 82, living room 84, den 86, children's playroom 88 and a garage 90 having a garage door 93. The garage is accessed by a driveway 91. A garden 92 is located to the right of ground floor 80.

The remote-control system preferably comprises a communications network in which command signals and data signals are transmitted as unfocussed ultrasound signals. Command signals and data signals are transmitted between different rooms in ground floor 80 by ultrasound combination units. The ultrasound combination units are installed in electrical junction box recesses 100, 102, 104 and 106 (shown covered by round cover plates) in walls of ground floor 80. Power from power lines in junction boxes in recesses 100, 102, 104 and 106 is supplied respectively to power outlets 101, 103, 105 and 107. Preferably, the combination units in junction box recesses 100, 102, 104, and 106 control power to outlets 101, 103, 105 and 107 respectively. A transceiver 110, similar to that shown in Fig. 1B is mounted on a wall 112 of children's' playroom 88 to transmit command signals between children's playroom 88 and garage 90. A similar transceiver 114 is mounted on wall 116 to transmit command signals from den 86 to driveway 91. Transceivers 113 and 115 are installed in kitchen 82 to transmit command signals between kitchen 82 and children's room 88 and garden 92 respectively. Command signals and data signals can therefore be transmitted from any room in ground floor 80, garage 90 and garden 92 to reach an appliance in any other room in ground floor 80 or an appliance in garage 90 or garden 92. For convenience of presentation combination units will be

referred to by the numerals labeling the recesses in which they are installed, i.e. combination unit installed in recess 104 will be referred to as "combination unit 104".

A stationary control unit 118 is located on a wall 120 of living room 84. Stationary controller 118 preferably comprises a chargeable battery (not shown) that supplies power to operate stationary controller 118. Preferably, stationary unit 118 also comprises a photocell (not shown) that generates electricity from ambient light in living room 84 to charge the battery. Stationary control unit 118 preferably comprises two control buttons 122 and 124. Control buttons 122 and 124 are used to control power to power outlets in recesses 101 and 103 respectively. When control button 122 is depressed, an ultrasound command signal is generated that comprises an address that is the same as the address that identifies combination unit 102. The command signal encodes "action data" in response to which combination unit 102 opens or closes a switch that supplies power to the power-outlet in recess 102. A lamp 126 plugged in to the power-outlet is turned off or on accordingly. Depressing control button 124 similarly turns on or off power to a lamp 128.

A television 130 is located in children's room 88. Television 130 is controllable to be turned on or off by an IR controller 132. IR controller 132 is connected to an activation module 134 similar to activation module 60 shown in Fig. 1D. Signals from activation module 134 control IR controller 132 to generate IR control signals that turn on and turn off television 130.

A sprinkler system 136 in garden 92 is controlled by RF signals that it receives on an antenna 138 from an RF controller 140. RF controller 140 is connected to an activation module 142 that controls RF controller 140 to generate control signals that turn on and off sprinkler system 92.

Fig. 2B shows a man in living room 84 operating a hand held controller 150 (greatly exaggerated in size) that generates command signals in accordance with a preferred embodiment of the present invention. In Fig. 2B and figures that follow, a command signal that is outgoing from a unit (*i.e.* a command signal generated by a controller, transceiver, combination unit) is indicated by an arrow that increases in width from tail to head pointing away from the unit. An arrow that decreases in width from tail to head pointing towards a unit indicates a command signal that is being received by the unit. The man is sending a command signal 152 to shut off television 130 in children's room 88, which is being watched by two children. Command signal 152 encodes the address that identifies activation module 134 that controls IR controller 132.

Command signal 152 is received by combination units 100, 102 and 104. However, only combination unit 104 is programmed to retransmit a command signal comprising the address identifying activation unit 134. Combination unit 104 retransmits command signal 152 into den 86 where it is sensed by combination unit 106. Combination unit 106 retransmits command signal 152 into children's room 88 where it is sensed by activation unit 134. Activation unit 134 checks the address encoded in command signal 152 and determines that the address is the same as its own address. Activation unit 134 therefore "follows the instructions" in command signal 152 and causes IR controller 132 to generate an IR signal, indicated by dotted line 154, that shuts off television 130.

In Fig. 2C the man operates hand controller 150 to send a command signal 156 that turns on lights 158 and 160 in garage 90 and over driveway 91 respectively. Lights 158 and 160 are connected to activation modules 162 and 164 respectively. In some preferred embodiments of the present invention, both activation modules 162 and 164 have a same identifying address. Lights 158 and 160 are therefore controlled to turn on or off simultaneously by a same command signal. Command signal 156 is received and transmitted by combination units 104, 106 and transceiver 110 to reach activation module 162 and turn on light 158. Command signal 156 reaches activation module 164 via combination unit 104 and transceiver 114 to reach activation module 164 and turn on light 160.

Activation modules 162 and 164 generate data signals that indicate whether lights 158 and 160 respond appropriately to command signals that they receive. If light 158 or 160 does not turn on in response to command signal 156 then activation unit 162 or 164 respectively generates a data signal alerting the man that the light 158 or 160 did not turn on. For example, if light 160 did not turn on, activation unit 164 would generate a data signal that would be transmitted by transceiver 114 and combination unit 104 to controller 150. Controller 150 preferably comprises a flat screen or indicator lights on which to present to the man in appropriate format, information, in this case that light 160 did not turn on, encoded in data signals.

Preferably, control module 164 also controls garage door 93. Control module 164 therefore responds to two identification addresses, one for light 160 and one for garage door 93. In some preferred embodiments of the present invention, control module 164 is programmed to turn on light 160 when it receives a command signal to open garage door 93. In addition, preferably, it generates a data signal indicating that it has received a command signal to open garage door 93. In some preferred embodiments of the present invention, in which

control modules 162 and 164 do not share an identifying address, preferably, the data signal is transmitted by the communication network to control module 162. In response to the data signal from control module 164, control module 162 turns on light 158. Preferably, control module 164 comprises a photosensor (not shown). If the photosensor detects daylight, control module 164 does not turn on light 160 and does not generate a data signal that causes control module 162 to turn on light 158.

Fig. 2D shows the man and his wife. The man operates controller 150 to send a command signal 170 to start sprinkler system 136. Command signal 170 comprises the address of activation module 142. Whereas all combination units in living room 84 receive command signal 170 only combination unit 100 retransmits command signal 170. When signal 170 reaches activation module 142, activation module 142 generates a control signal that controls RF transmitter 140 to radiate an RF control signal, indicated by a broken arrow 172, that turns on sprinkler system 136. The man's wife is depressing button 124 on stationary control unit 118 to turn off light 128. Stationary controller 118 generates a command signal 180 that encodes the address of combination unit 100 and instructions to shut off power to light 128. When combination unit 100 receives command signal 180, combination unit 100 switches off power to outlet 101 and thereby to light 128. Because command signal 180 encodes the address of combination unit 100, combination unit 100 does not retransmit command signal 180.

The present invention has been described using non-limiting detailed descriptions of preferred embodiments thereof. Variations of the embodiments described will occur to persons of the art. For example, a controller may be controllable by signals transmitted to the controller over a telephone line. A controller may comprise a clock and be programmable to transmit command signals to activation modules of various appliances as a function of time. Activation modules also may comprise a clock and be programmable to operate an appliance responsive to a clock signal.

It should also be noted that, whereas the detailed descriptions refer to remote-control systems installed in a home, remote-control systems in accordance with preferred embodiments of the present invention can be installed to control devices in many different environments and structures. For example, remote-control systems in accordance with preferred embodiments of the present invention can be installed to control equipment in factories or in ocean liners.

Furthermore, remote-control systems comprising different combinations and types of controllers, activation modules and transceivers can be provided and/or tailored to different tasks. For example, a remote-control system in accordance with a preferred embodiment of the

present invention can be provided to control an intercom system providing voice communication between people in different offices in a building. Speakers and microphones in the offices can be selectively turned on and off by the remote-control system to provide different communication configurations between people in the offices.

In addition, different methods of encoding data in ultrasonic command signals other than the method described are possible and can be advantageous and such methods will occur to persons of the art.

The detailed descriptions are provided by way of example and are not meant to limit the scope of the invention, which is limited only by the following claims. In the claims and description of the present application, the verbs, "comprise" "include" and "has", and conjugates thereof, are used to indicate that the object or objects of the verb are not necessarily a complete listing of components, elements or parts of the subject or subjects of the verb.

CLAIMS

1. A remote-control system for controlling a plurality of devices located in different rooms of a structure and areas in the vicinity of the structure comprising:

at least one user operated controller for generating wireless command signals encoding data;

a control unit for each of the plurality of devices that receives wireless command signals generated by the at least one controller and controls a device responsive to data in a wireless command signal that it receives;

a wireless communications network comprising at least one transceiver that transmits wireless command signals from one side to the other of a wall of the structure;

wherein the at least one controller transmits command signals that are routed to a control unit of a device of the plurality of devices through the at least one transceiver.

2. A remote-control system according to claim 1 wherein each control unit is identified by an address.

3. A remote control system according to claim 2 wherein at least one controller encodes data that identifies an address of a control unit of a device and an action for the device to execute in a wireless command signal that the at least one controller transmits and when the control unit identified by the address receives the wireless command signal the control unit controls the device to execute the action.

4. A remote-control system according to claim 3 wherein the at least one transceiver selectively transmits a wireless signal that it receives from one side of the wall to the other side of the wall responsive to the address encoded in the wireless signal and from which side of the wall the command signal is received.

5. A remote-control system according to claim 4 wherein the at least one transceiver comprises a memory stored with an address of at least one of the control units.

6. A remote-control system according to claim 5 wherein the at least one transceiver transmits a wireless command signal from one to the other side of the wall responsive to the address stored in the memory.

7. A remote-control system according to claim 5 or claim 6 wherein addresses in the memory are changeable.

8. A remote-control system according to any of claims 2 – 7 wherein a control unit of at least one of the plurality of devices comprises a transceiver.

9. A remote-control system according to claim 8 wherein when the transceiver receives a wireless command signal generated by the at least one controller having an address that is the same as the address of the control unit, the control unit controls the at least one of the plurality of devices to execute an action defined by data encoded in the wireless command signal.

10. A remote control system according to any of the preceding claims wherein at least one control unit connects or disconnects power from a junction box to at least one power outlet by controlling at least one switch that connects or disconnects a wire from the at least one power outlet to or from a power line in the junction box.

11. A remote-control system according to claim 10 wherein the at least one control unit and switch are located in the junction box.

12. A remote-control system according to any of the preceding claims wherein at least one control unit senses information relevant to the functioning of a device of the plurality of devices that the control unit controls.

13. A remote control system according to claim 12 wherein the at least one control unit controls the device responsive to the information.

14. A remote control system according to claim 12 or claim 13 wherein the at least one control unit generates wireless data signals encoding the information.

15. A remote-control system according to claim 14 wherein at least one control unit generates wireless data signals responsive to wireless command signals that the at least one control unit receives from a controller of the at least one controller.

16. A remote-control system according to claim 14 or claim 15 wherein at least one controller comprises a receiver for the wireless data signals.

17. A remote-control system according to claim 16 wherein the at least one controller comprises a display which displays information encoded in wireless data signals that it receives.

18. A remote control system according to claim 16 or claim 17 wherein the at least one controller generates wireless command signals to control a device responsive to wireless data signals that it receives.

19. A remote-control system according to any of claims 14 – 18 wherein at least one control unit comprises a receiver for the wireless data signals and controls a device of the plurality of devices responsive to wireless data signals that it receives.

20. A remote control system according to any of claims 14 – 19 wherein at least one control unit generates wireless data signals that are transmitted to their intended receivers via the communication network.

21. A remote-control system according to any of the preceding claims wherein at least one controller is a hand held controller.

22. A remote-control system according to any of the preceding claims wherein at least one controller is a controller mounted in a fixed position.

23. A remote-control system according to any of the preceding claims wherein the wireless signals are ultrasound signals.

24. A remote-control system according to claim 23 wherein each of the ultrasound signals comprises a pulse train of ultrasound pulses.

25. A remote-control system according to claim 24 wherein sound waves in each ultrasound pulse are restricted to a narrow band of frequencies centered about a central frequency.

26. A remote-control system according to claim 25 wherein the central frequency for each ultrasound pulse is a frequency of a plurality of frequencies in a band of frequencies having a minimum frequency and a maximum frequency.

27. A remote-control system according to claim 26 wherein the minimum frequency is greater than or equal to 35 kHz.

28. A remote-control system according to claim 26 or claim 27 wherein the maximum frequency is less than or equal to 48 kHz.

29. A remote-control system according to any of claims 24 – 28 wherein the ultrasound pulses in the pulse train have a same duration.

30. A remote-control system according to claim 29 wherein the pulse rate for the pulse train is constant.

31. A remote-control system according to any of the previous claims wherein at least one controller is programmable to generate wireless command signals responsive to a program.

32. A remote-control system according to claim 31 wherein the at least one controller comprises a clock that provides timing signals and the at least one controller is programmable to generate wireless command signals responsive to the timing signals.

33. A remote-control system according to any of the preceding claims wherein at least one controller is operable to transmit command signals responsive to signals transmitted through a telephone.

34. A remoter-control system according to any of claims 23 - 33 wherein at least one controller generates a wireless electromagnetic signal in addition to an ultrasound command signal when the at least one controller generates an ultrasound command signal.

35. A remote-control system according to claim 34 wherein at least one control unit comprises a receiver that receives electromagnetic signals and when the at least one control

unit receives an electromagnetic signal and an ultrasound command signal, the at least one control unit activates a device responsive to a time difference between the arrival of the electromagnetic signal and the ultrasound signal.

36. A remote-control system according to claim 34 or claim 35 wherein the electromagnetic signal is an RF signal.

37. A remote-control system according to claim 34 or claim 35 wherein the electromagnetic signal is an IR signal.

38. A control unit for controlling power to at least one power outlet from a junction box to which power is provided on at least one power line comprising:

at least one switch mounted in the junction box that selectively connects a power line in the junction box to a wire from each of the at least one power outlet that brings power from the junction box to the power outlet;

a receiver that receives wireless command signals from a controller of the at least one controller that encode data; and

circuitry that controls the at least one switch to selectively connect the wire to a power line in the junction box responsive to the data in a wireless command signal that it receives.

39. A control unit according to claim 38 wherein the control unit senses information relevant to power supplied from the junction box to the at least one power outlet and controls the at least one switch responsive to the information that it senses.

40. A control unit according to claim 39 wherein the control unit comprises circuitry that generates data signals that encode information that the control unit senses.

41. A control unit according to claim 39 or claim 40 wherein the control unit senses if a load is connected to the at least one power outlet and if a load is not connected to the power outlet, disconnects the wire that supplies power to the at least one power outlet from the power line.

42. A control unit according to any of claims 39 – 41 wherein the control unit senses power supplied to each of the power outlets and disconnects power to an outlet in case of overload of the outlet.

43. A control unit according to any of claims 39 - 41 wherein the at least one power outlet comprises a plurality of power outlets.

44. A control unit according to claim 43 wherein the at least one power line comprises a plurality of power lines.

45. A control unit according to claim 44 wherein the control unit senses the amount of power supplied to the plurality of power outlets on each of the plurality of power lines and connects wires that provide power to the power outlets from the junction box to the power lines so that each of the power lines provides substantially the same amount of power to the power outlets.

46. A control unit according to claim 44 or claim 45 wherein each power line that provides power to the junction box provides power from a different phase of a multiphase power source.

47. A control unit according to any of claims 38 – 46 wherein the wireless command signal is an ultrasound signal.

48. A controller according to any of claims 40 – 47 wherein the data signal is a wireless data signal.

49. A controller according to claim 48 wherein the data signal is an ultrasound signal.

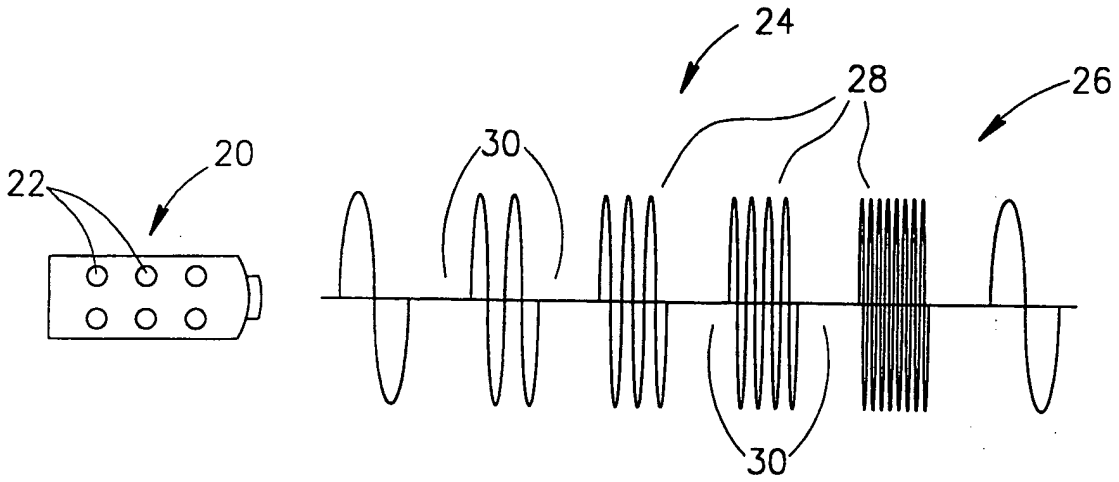
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FIG.1A

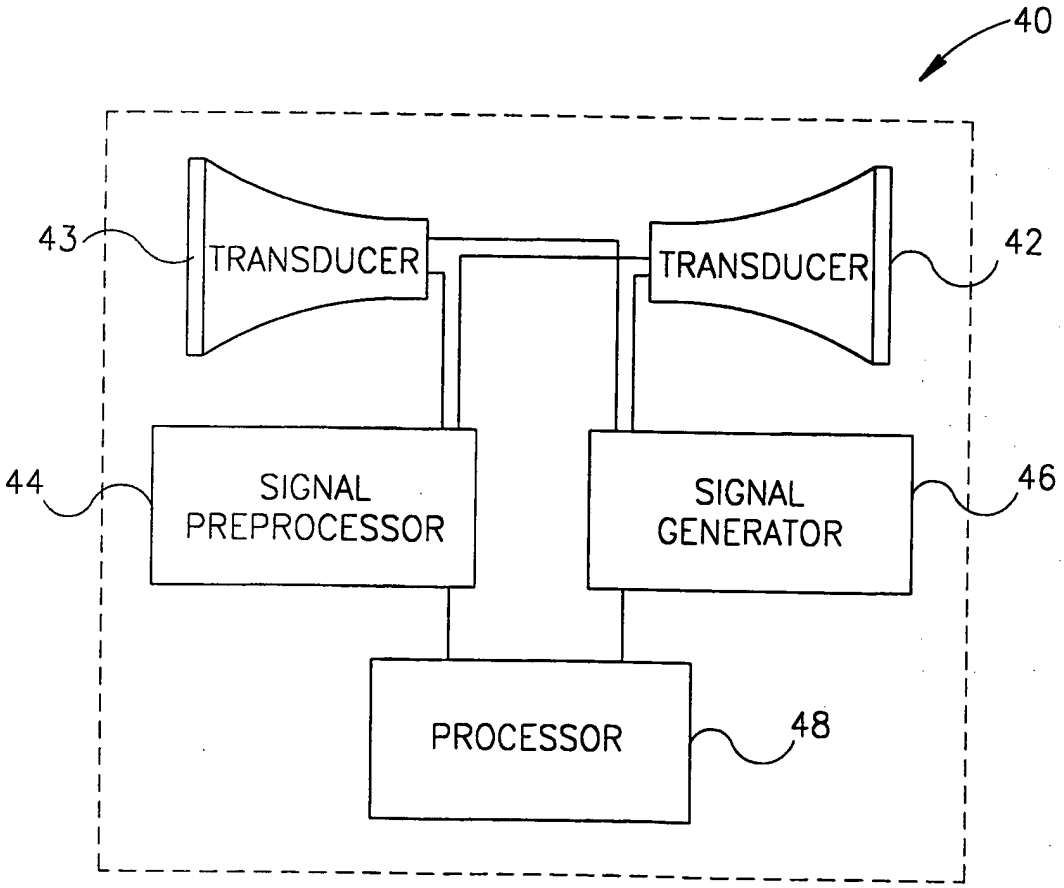
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FIG.1B

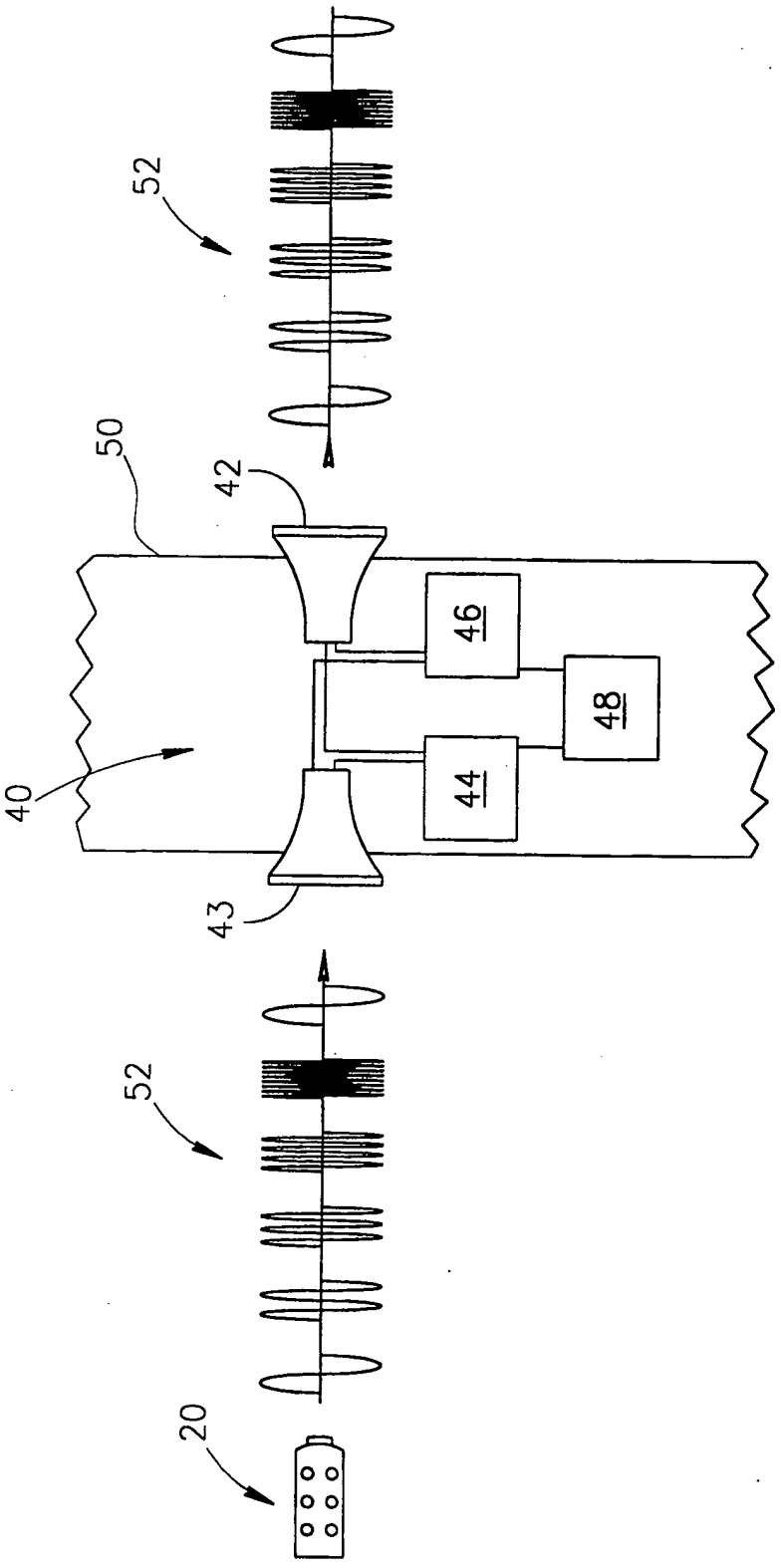

FIG.1C

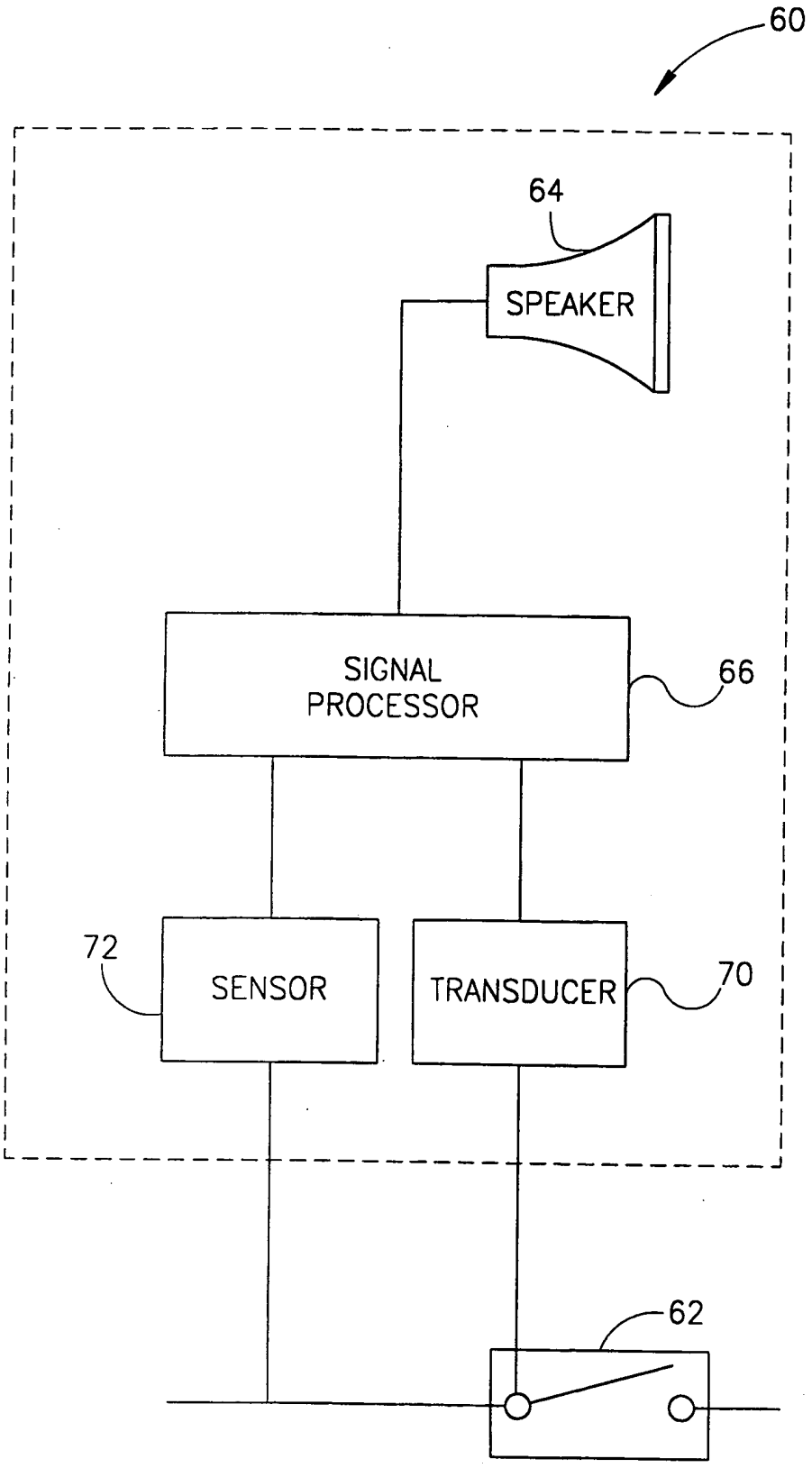
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FIG.1D

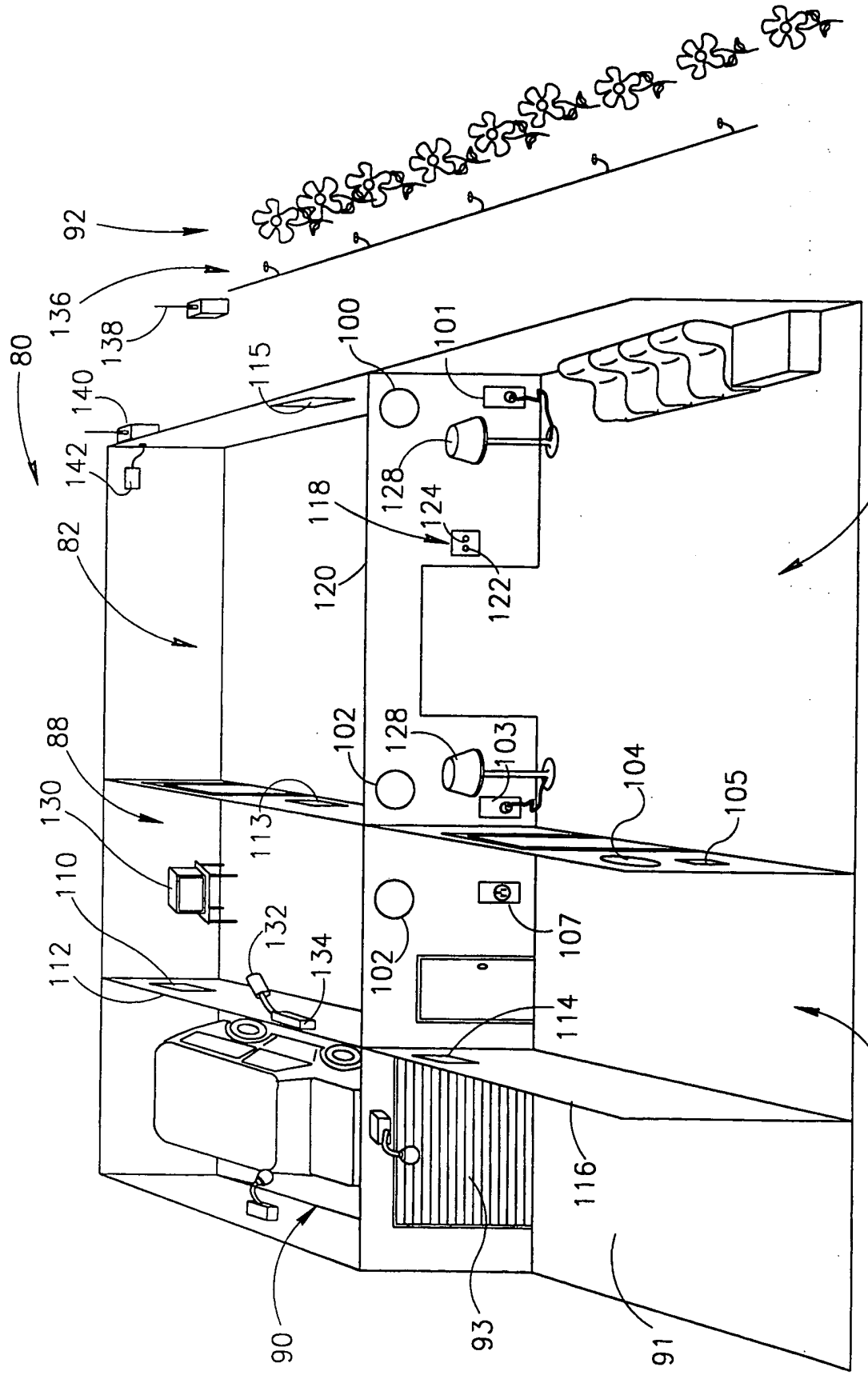
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FIG.2A

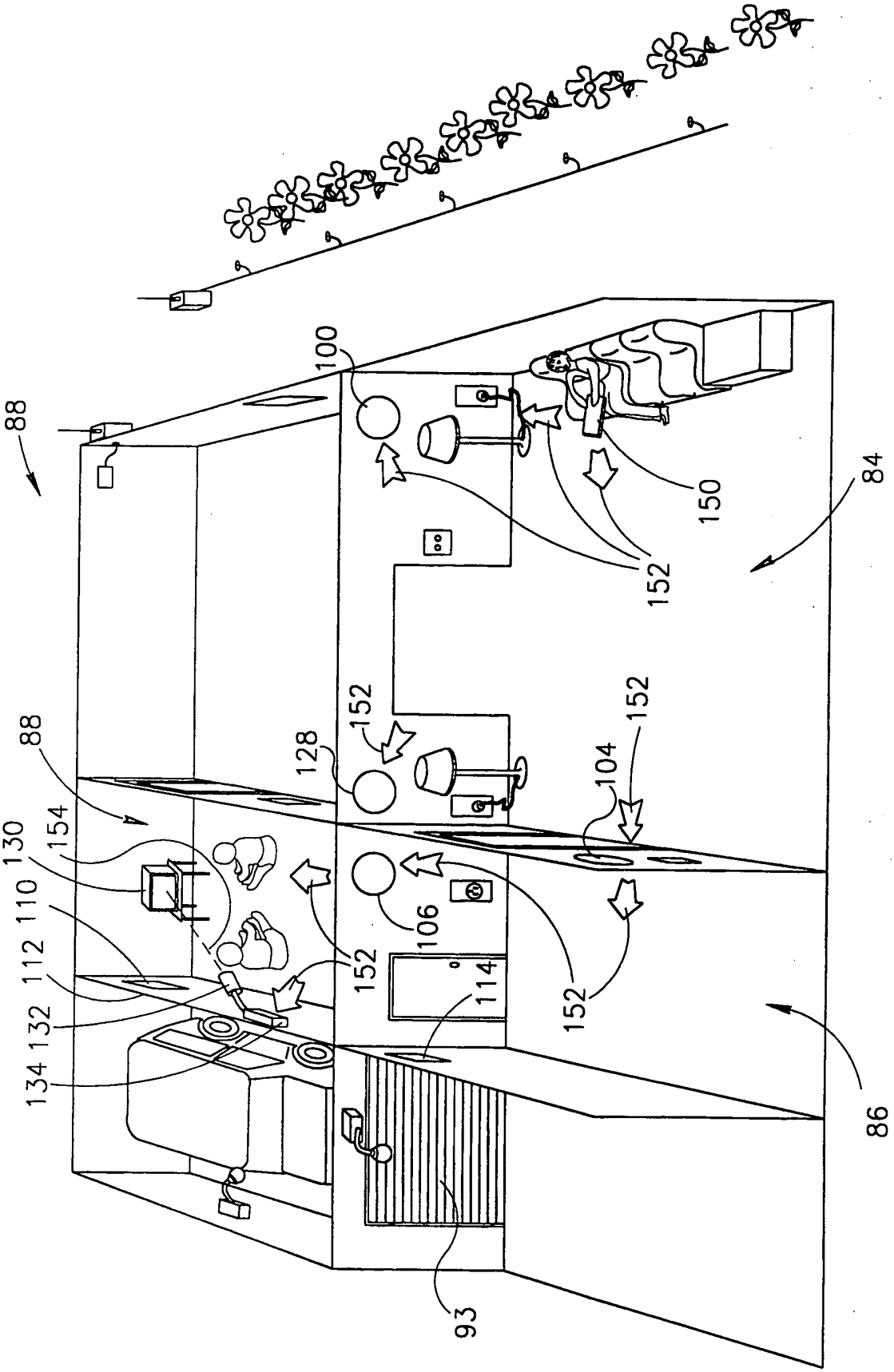
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FIG.2B

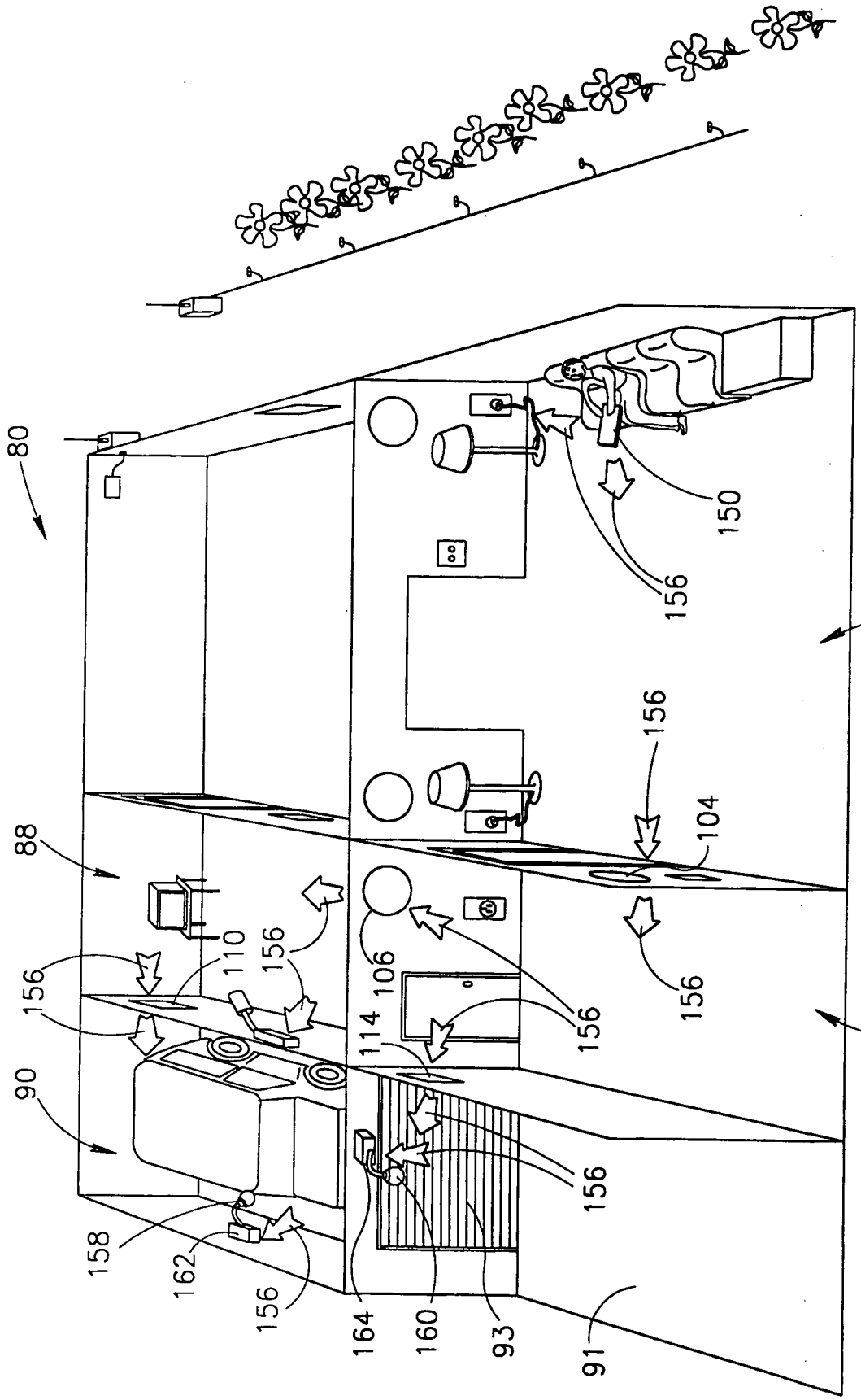
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FIG.2C

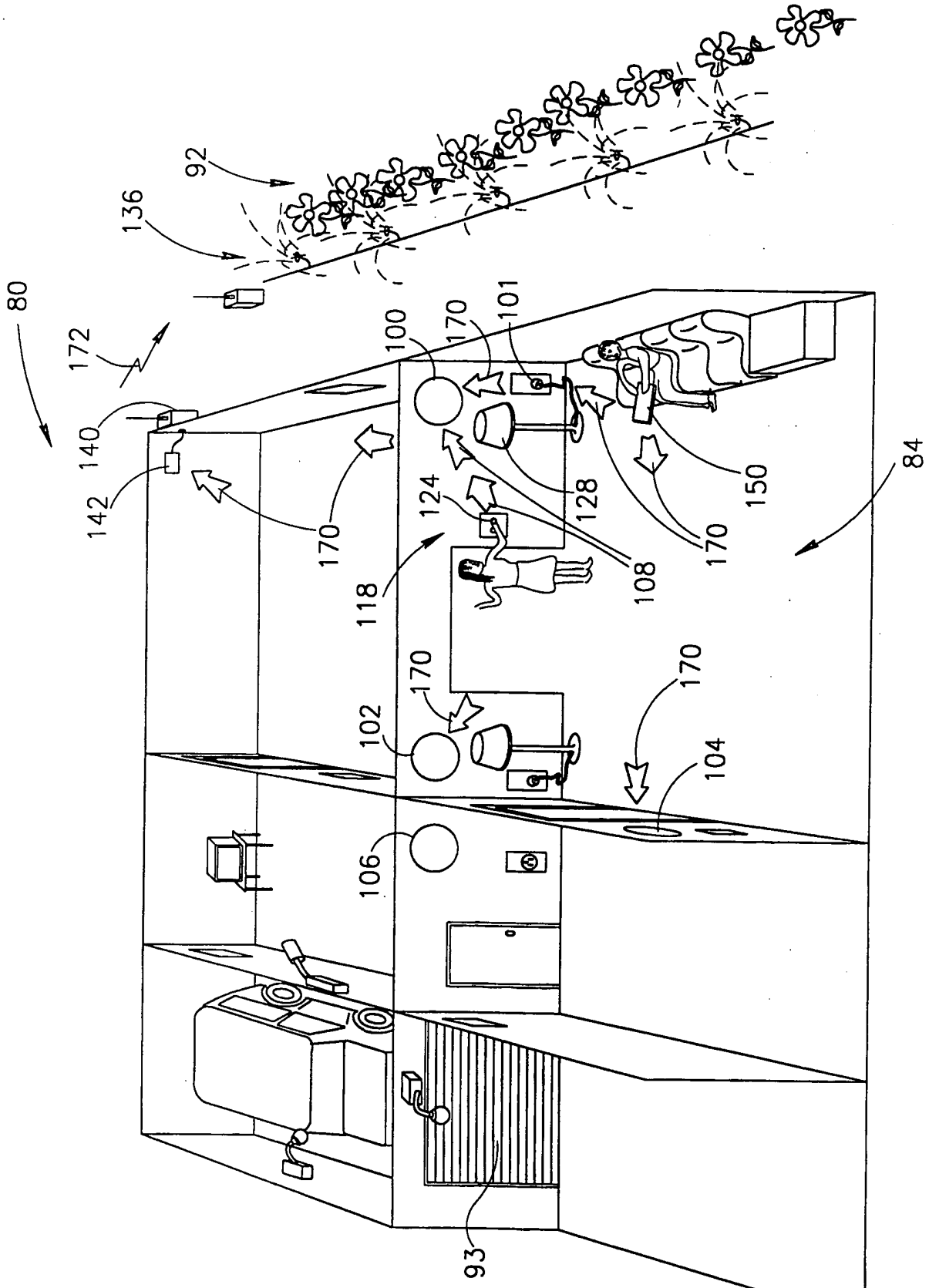
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FIG.2D

INTERNATIONAL SEARCH REPORT

Int[illegible]ional Application No
PCT/IL 99/00189

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G08C23/02 H04B11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G08C H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 838 226 A (HOUGGY DAVID E ET AL) 17 November 1998 .(1998-11-17)	1-3,8,9, 12, 14-17, 20,22
A	column 12, line 16 -column 13, line 28 column 17, line 22 - line 54 column 18, line 37 -column 22, line 33 column 24, line 52 -column 25, line 33	4-7,18, 19,21, 39-42,48
X	GB 2 303 945 A (GOODFELLOW JAMES) 5 March 1997 (1997-03-05)	1,21-24
A	page 9, line 18 -page 13, line 22	15-18, 47,49

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 December 1999	13/12/1999

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